PATENT SPECIFICATION

681,098

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COMPLETE SPECIFICATION

Hypo-Jet Injector

I, STANLEY GUSTAV DEHN, M.A., of Kingsway House, 103 Kingsway, London, W.C.2, a British subject, Chartered Patent Agent, do hereby declare the nature of this invention (a communication to me from R. P. Scherer Corporation, a corporation duly organized under the laws of the State of Michigan, of 9425 Grinnell Avenue, Detroit 13, State of Michigan, United States of America), and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement :—

This invention relates to an injector for hypodermically injecting fluid by the jet therapy method.

One object of the invention is to provide an injector which is practical from both the manufacturing and utility standpoints, and efficient as a means to cause a true jet type of injection. Heretofore hypodermic injection without a needle was attempted as evidenced by British Specification No. 568,237.

In this and other prior publications, methods and means are described through which a two-stage injection may be accomplished. The first of these two stages is carried out under high pressure on the liquid so that a high velocity jet is produced which penetrates the skin, while in the second stage the pressure on the liquid is lower, said second stage being intended to cause the injected liquid to spread out at the depth under the surface of the skin to which it was injected during the first stage.

In these prior injection devices the change from the first to the second stage of the injection process occurred gradually. The injection ampoule employed had a plunger actuated by a spring or by other energy storing means which upon sudden release delivered a sudden burst of energy to the plunger, the force of which gradually diminished as the plunger moved forward and ejected the liquid.

The main objection to these prior methods and devices is the fact that it is difficult to control the rate of reduction in the driving force causing the ejection and for this reason it is practically impossible to determine the depth of penetration of the jet in the first stage of said two-stage operation.

Therefore, a further object of the present invention is to provide an injector of the two-stage injection type in which means are provided to ensure a sudden sharp drop in pressure at the end of the initial high pressure injection stage.

Another object of the present invention is to provide a spring-propelled type of mechanism which can be used in connection with a hypodermic jet ampoule of the kind disclosed in co-pending application No. 18012/49, filed 7th July 1949, to operate the follower behind the medicament in the ampoule in such manner as to effect true jet therapy with a mechanism that is of practical size and weight for average use and is not prohibitively complicated to operate.

A further object is to provide either two plungers operated by a single spring or a single plunger operated by two springs in such manner as to secure the desired two-stage jet, that is a primary or initial high-pressure, high-velocity penetrating jet and a secondary follow-through jet which has a pressure and velocity much lower than the penetrating jet.

Still a further object is to provide these two-stage arrangements in order to utilize a comparatively light spring for at least part of the operation as distinguished from a single stage operation in the said British Specification No. 568,237 in which case the spring has to be many times heavier than I disclose in order to produce an initial high-pressure jet. The pressure for the follow-through jet need only be sufficient to produce follow-through action after cessation of the penetrating action of the initial jet, the major portion of the injection operation merely feeding the medicament into the initial jet-opened channel to thereby result in lateral flow of the medicament from the bottom of the channel and result in a desired injection pattern which is thus under accurate control as to the depth of the injection.

[Pric

An additional object is to provide an injector so constructed that the initial or high-pressure penetrating jet can be decreased by less spring tension, or increased by greater spring tension and/or by providing for a primary plunger to strike the follower with impact and a secondary plunger to provide the follow-through action depending upon the construction and proportion of the parts of the injector.

Another additional object is to provide a modified form of the invention in which a relatively heavy spring acts on a single plunger to provide an initial penetrating jet and after expulsion of a minor portion of the medicament a relatively light spring continues the movement of the same plunger to result in producing the follow-through jet.

With these and other objects in view, my invention consists in the construction, arrangement and combination of the various parts of my hypo-jet injector whereby the objects contemplated are attained, as hereinafter more fully set forth, pointed out in my claims and illustrated in the accompanying drawings, wherein:

Figure 1 is a sectional view through a hypo-jet injector embodying one form of my invention having primary and secondary plungers and a single spring, and showing the parts in position for an injection operation;

Figure 2 is a bottom plan thereof;

Figure 3 is a detail sectional view on the line 3—3 of Figure 1;

Figure 4 is a view similar to Figure 1 showing the primary plunger operated to provide a high pressure penetrating jet and illustrating the projection of this jet to the fascia plane of the muscle;

Figure 5 is a similar view showing the low-pressure follow-through jet produced by operation of the secondary plunger and effecting lateral flow of the medicament, the injection illustrated being one in the fascia itself;

Figure 6 is a greatly enlarged sectional view through the end of the jet injection ampoule which contacts the epidermis in order to illustrate the hydraulic seal between the ampoule and the epidermis;

Figure 7 is a view similar to Figure 1 showing the proportion of the parts for utilizing impact;

Figure 7a is an enlarged sectional view showing a modified construction;

Figure 8 is a graph showing pressure-time curves for a number of different operating mechanisms and conditions;

Figure 9 is a sectional view through a modified form of hypo-jet injector showing a single-plunger, two-spring type with the parts in position for an injection operation;

Figure 10 is a view similar to Figure 9 showing a relatively heavy spring expanded to provide a high-pressure penetrating jet and illustrating the projection of this jet to the fascia above the muscle;

Figure 11 is a similar view showing the low-pressure follow-through jet produced by operation of a relatively light spring on the same plunger and effecting lateral flow of the medicament;

Figure 12 is a sectional view similar to Figure 9 showing still another modification using a single plunger and two springs; and

Figure 13 is a view showing a stage in the operation similar to Figure 10 but illustrating the modification of Figure 12.

On the accompanying drawings, I have used the reference character A to indicate an ampoule of the general type shown in my above mentioned co-pending application. The ampoule A comprises a cylindrical wall 10 terminating in a rounded end 12 and having a holding flange 14 at its other end. The rounded end 12 is provided with a jet orifice 16 shown particularly in Figure 6 which should be anywhere from .002" to .005" in diameter.

The small size of the jet orifice is necessary to secure a jet discharge of the medicament illustrated at 18 with high velocity so as to penetrate or puncture the epidermis 20 and the underlying dermis 22 with a hole that is of minimum size, to minimize trauma yet produce a jet-formed passageway into the underlying tissues such as the fat cells 24, the fascia 26 or the muscle 28 as desired and yet accomplish the injection with imperceptible or at least minimum pain. In this respect I have found that a jet orifice of .003" diameter produces what might be termed a "microjet" when suitable hydraulic pressure is created on the medicament 18 to form a liquid column which is about the size of a mosquito's proboscis and only 1/37th of the area of a 26 gauge hypodermic needle, this size of needle being about the smallest practical size in use at present.

The medicament 18 may be any suitable drug, fluid medicament or solution and so far I have found my hypo-jet therapy method suitable for use with many different liquids among which I might mention insulin, a preparation sold under the Registered Trade Mark "diodrast", cocaine, penicillin, streptomycin, liver extract, promin, and procaine, as well as India ink, mercury, and metallic mercury, many different aqueous solutions, colloidal suspensions, oil solutions and emulsions which were injected into cadavers for the purpose of determining (1) depth of penetration under varying conditions and (2) the injection patterns resulting therefrom.

In the ampoule A, I provide a follower F of rubber or the like preferably in the form of a central diaphragm 30 and a depending

flange 32, the follower being thus in the form of a cup-like plunger. This follower backs up the medicament, and the ampoule is preferably filled in such manner that there are no air bubbles present in the ampoule to interfere with proper operation of the injector because bubbles would be highly compressible as distinguished from the liquid itself.

My hypo-jet injector comprises a holder for the ampoule A and operating means within the holder for the follower F. The holder and operating mechanism of Figures 1 to 5 will now be described.

A barrel 34 forms the body of the injector and has a cup-shaped lower head 36 connected thereto as by the screw threads illustrated at 38. The head 36 has a recess 40 receiving the flange 14 of the ampoule A and the ampoule may be held with its flange in the recess as by means of a retainer plate 42 pivoted at 44 and having a notch 46 to hook under the head of a shoulder screw 48. The latch plate 42 also has a notch 50 to receive the diameter of the ampoule A and may be swung to the dotted position shown in Figure 2 for permitting removal of one ampoule and insertion of another. A lip 52 on the latch plate is provided as an aid in swinging the plate.

Within the barrel 34 a primary cup 54 is slidable and is normally urged in a downward direction by a spring 56 interposed between the lower wall of the cup and a partition 58. A secondary cup 60 is slidable in the head 36. A primary plunger 62 is connected with the primary cup 54 and the secondary cup 60 has a tubular extension 64 surrounding the primary plunger 62 which serves as a secondary plunger. The plunger 64 is guided by a central opening 66 in the head 36 and is biased upwardly to the position illustrated in Figure 1 by a light spring 68. In this position, the flange of the cup 60 is stopped by the lower end of the barrel 34.

For compressing the spring 56 to the position shown in Figure 1, I provide a pull rod 70 connected with the cup 54 and terminating in a knob 72. The pull rod 70 has a latch shoulder at 74 with which a latch plate 76 is biased to coact by means of a spring 78. The latch shoulder of the plate 76 is illustrated at 80. The pull rod is guided by a cap 82 screwed on the upper end of the barrel 34.

Referring to Figure 7 the hypo-jet injector disclosed therein is similar to the ones shown in Figure 1 except that the cup 54 is higher than the barrel 34 in the cocked position of the injector and thereby raises the primary plunger 62 out of contact with the wall 30 of the follower F. Accordingly, before the parts reach the position shown in Figure 1 there is travel of the primary plunger 62 which produces an impact against the wall 30 at the time the parts reach the position of Figure 1 so that this impact is added to the initial high-pressure stage of operation which terminates when the parts reach the position of Figure 4 and after which the low pressure stage of the operation as illustrated in Figure 5 finishes the jet injection.

In order to raise the plunger 62 enough in Figure 7 to secure impact as just described the portion of the barrel 34 above the partition 58 is made longer so that the latch plate 76 can be mounted higher and therefore hold the shoulder 74 at a higher elevation in the latched position.

In the embodiment of the invention shown in Figures 9–11 a single plunger 63 is provided and it is connected with the cup 54, the plunger 64 and its cup 60 in Figure 1 being entirely eliminated. The spring 56 is still provided as in Figure 1 but in addition to this spring a second spring 90 which is much stiffer is utilized to initially propel the single plunger 63 to produce the high pressure penetrating jet. As illustrated this spring may comprise a stack of spring discs which are cupped and therefore relatively stiff and in fact much stiffer than the coil spring 56. The discs 90 are perforated at their centers and surround the pull rod 70, a washer 92 being interposed between them and the upper end of the cup 54.

In Figures 12 and 13 a relatively heavy coil spring 91 is provided in place of the discs 90 and the washer 92 below them is confined in its movement by an inturned flange 94 in the barrel 34. The pull rod 70 may then be provided with a shoulder 96 adapted to at times engage the washer 92 for a purpose which will hereinafter appear.

In Figure 7a I show a preferred shape for the primary plunger 62 in order that the follower diaphragm 30 will collapse completely against the flange 32 of the follower. This is accomplished by providing a bullet shaped end 62a on the plunger 62 of substantially similar shape to the rounded end 12 of the ampoule A itself so that no liquid will be left in the ampoule when the plungers are all the way down as is possible with the arrangement shown in Figure 5. Also the single plunger 63 of Figure 11 can be shaped as shown for both plungers 62 and 64 in Figure 7a so that liquid is not left in the ampoule as in Figure 11.

PRACTICAL OPERATION OF FIGURES 1 TO 5

The parts are caused to assume the position of Figure 1 by pulling the knob 72 upwardly from the position of Figure 5 to the position of Figure 1 whereupon the latch plate 76 snaps to position under the shoulder 74 of the rod 70. The spring 56 is thus compressed and latched in the compressed position. In the position of Figure 5, it is

desirable that the spring also be somewhat compressed to provide complete follow-through jet operation as will hereinafter appear. When a hypo-jet injection is to be made, an ampoule with proper medicament therein is placed in the recess 40 while the retainer plate 54 is in the dotted position of Figure 2 and the retainer plate is then swung to the full line position for retaining the ampoule in operating position. The injector is then ready for performing the jet injection operation.

The injector is held usually at right angles to the skin surface where the injection is made and the ampoule is pressed against the epidermis 20 as illustrated in Figures 4 and 6 to effect a hydraulic seal between the edge of the jet orifice 16 and the epidermis.

The end 12 of the ampoule is preferably rounded or bullet shaped so as to form an acute angle between the wall of the orifice and the adjacent outer surface of the ampoule, whereby pressure is obtained against the epidermis right at the edge of the orifice itself, although I have found that the lower end may be honed off or polished to provide a narrow marginal flat spot surrounding the orifice and still provide an effective hydraulic seal between the ampoule and the epidermis. The epidermis of course will bulge into the orifice slightly thus increasing the effectiveness of the seal.

If such a seal is not effected I have found that a film of liquid results between the ampoule and the epidermis which results in "skidding" of the injector when it is operated with the result that a series of injections along an irregular path is produced, none of which are of the proper depth and much of the medicament is lost, that which is injected being improperly injected. The result is painful and produces an undesirable slit in the patient's skin and the attendant necessity of healing the slit. It is therefore important that the hydraulic seal referred to be produced prior to injection and in fact maintained for a second or so after injection in order to ensure that all the medicament of the follow-through jet will then be properly injected.

To accomplish injection, the latch plate 76 is pushed toward the left in Figure 3 which unlatches the shoulder 80 from the shoulder 74 and permits the spring 56 to expand. The primary cup 54 is propelled thereby until it strikes the secondary cup 60 and during this time the primary plunger 62 is acting on the follower F, causing its diaphragm portion 30 to be stretched and the follower partially turned "wrong side out" as illustrated in Figure 4. Since the plunger 62 is relatively small in diameter it produces very high pressure in pounds per square inch (PSI) in the ampoule A. This results in displacing the medicament 18 through the jet orifice 16 and produces a true jet as shown at 84 in Figure 4 because the high pressure produces high velocity of the medicament due to its issue from an opening as small as the jet orifice 16.

The high velocity of the liquid tends to keep it in the form of a column but the column becomes pointed at the forward end because of the resistance offered to its flow by the body tissues which tend to peel off the periphery of the jet, tissues of greater resistance increasing this effect. Thus, the jet may be visualized as in the form of a pointed needle and the jet actually pierces a hole or channel which deepens as the jet continues to flow at a high pressure that causes jet penetration. The jet encounters its first resistance when it strikes the epidermis but with relatively high velocity it can readily pierce the epidermis and will then more easily open a channel through the layer of fat underlying the skin and accordingly reach down relatively easily to the next layer which is the fascia. The penetrating jet has the property of distending the surrounding tissues to form a hole 86 against the natural elastic tendency of the tissues to return to their original positions thus closing the hole.

The fascia layer is tissue that is more resistant than fat to the passage of the jet. If the high pressure is reduced to low pressure at the time the jet enters the fascia an intrafascia injection 18a takes place as shown in Figure 5 as the low pressure follow-through jet merely feeds the medicament into the distended hole 86 made by the high pressure penetrating jet, and the liquid then spreads laterally as at 18a producing an injection pattern the size of which increases with the quantity of liquid fed through the hole 86 by the low pressure follow-through jet.

Referring to Figure 8, the pressure-time curve *a*, *b*, *c*, *d*, *e*, *f*, represents an average jet injection. When the pull rod 70 is first released the spring 56 moves the cup 54 downwardly causing the primary plunger 64 to press against the follower F, the pressure rise *a*, *b*, being that resulting from taking up all play in the parts. Pressure then begins to build up quite rapidly as represented by the curve *b*, *c*, while the primary plunger 62 is travelling from the position of Figure 1 to the position of Figure 4 whereupon the cup 54 strikes the cup 60.

During this rise of pressure which is very rapid, the jet 84 is projected from the jet orifice 16 and somewhere along the curve *b*, *c*, for instance at the point indicated as *b'* the jet velocity is sufficiently built up to puncture the epidermis. From *b'* to *c* the jet continues to be projected and accomplishes the desired

penetrating action and formation of the hole 86, for instance, to the depth of the fascia 26 in Figure 4. Due to the greater resistance of the fascia to the jet action the penetrating action is sharply reduced at this point and if the jet pressure is then reduced as from *c* to *d* no further penetration will take place. The remaining liquid can then be injected through the hole 86 and will follow the fibers of the fascia while a much lower follow-through pressure is in effect to introduce the remaining liquid from the ampoule into the hole 86. I have found that the pressure may be reduced to 20 or 25 per cent of the pressure required for the high pressure penetrating jet to reach the fascia layer.

The point *c* at which pressure reduces to *d* for the follow-through jet operation is represented in the injector itself by the lower end of the primary cup 54 striking the secondary cup 60 so that the spring 56 then moves the secondary plunger 64 in unison with the primary plunger 62. From *c* to *d* the follower is expanding and the ampoule is contracting from the sizes they assumed as a result of the high pressure produced for the penetrating jet. This operation, the low pressure follow-through jet, commences when the parts are in the position just described and which position is illustrated in Figure 4.

As the spring 56 continues to expand, its pressure will gradually drop which is represented by the decline of the curve from *d* to *e*. This decline will not be to zero because the spring is under some compression even in the position of Figure 5. However, when the secondary cup 60 reaches the upwardly projecting boss 65 around the opening 66 as in Figure 5 substantially all the medicament 18 has been injected to form the injection pattern 18a, and pressure then rapidly reduces to zero as the ampoule contracts due to the relief of pressure therein and the follower F expands also due to the relief of pressure and strain is removed from all the operating parts. This is represented by the curve section *e*, *f*.

If it is desirable that the jet 84 penetrate only part way down to the fascia plane, less travel of the primary plunger before the secondary plunger starts to move will accomplish this result. The parts of course can be proportioned to secure this result or any desired variation of it. By way of example another pressure curve has a peak at *c'* indicating that after break-through of the jet with respect to the epidermis at *b'* the penetrating jet operates for a shorter period of time and therefore doesn't penetrate as deeply. The peak *c'* accordingly will reduce the high pressure build-up, and the low pressure follow-through jet will commence operating a little sooner as indicated at *d'*. The same follow-through action is then had with the injected liquid being dispersed laterally in the fat tissues 24.

PRACTICAL OPERATION OF FIGURE 7

By proportioning the parts as in Figure 7 impact in addition to the maximum force of the spring 56 is had because the primary plunger 62 must travel a short distance before striking the follower F and when it does strike it will quickly build up the pressure to a higher value as indicated at *c''* before the pressure drops down for the low pressure follow-through action beginning at *d*. This higher pressure for the penetrating jet will cause it to pass on through the fascia 26 and into the muscle 28 so that an intramuscular injection can be made. Obviously, a stronger spring used in the Figure 1 arrangement will accomplish a result similar to impact.

PRACTICAL OPERATION OF FIGURES 9, 10 AND 11

This form of my injector is shown cocked in Figure 9, the initial pull on the rod 70 raising the cup 54 from the position of Figure 11 to the position of Figure 10 and in so doing further compressing the spring 56. Further movement of the pull rod 70 tends to flatten the discs 90 until they assume the shape shown in Figure 9 when the shoulder 74 is latched on the latch plate 76.

The ampoule A may then be secured to the injector and when ready for the injection the latch plate 76 is released whereupon the the initial movement of the plunger 63 is effected by the discs 90 expanding from the position of Figure 9 to the position of Figure 10. The relative stiffness of these discs produces the desired high pressure initial movement for causing the plunger 63 to expel the jet at penetrating pressure and velocity.

After the discs 90 have expanded so that their force is equal to the force in the compressed spring 56, the spring 56 will expand to produce the follow-through pressure desired for injecting the medicament laterally from the bottom of the channel 86 as in Figure 5.

The form of invention shown in Figures 12 and 13 operate substantially the same as the forms shown in Figures 9, 10 and 11, the initial penetrating jet pressure being produced by the spring 91 until the washer 92 strikes the flange 94. The shoulder 96 will then leave the washer 92 under continued expansion of the relatively weak spring 56, which spring then produces the follow-through jet at the desired reduced pressure.

In my discussion of jet injections thus far I have not taken into consideration the fact

that age, site of the injection and other factors effect the depth of injection. Babies and children have tissues that are less resistant to the jet and accordingly lower spring pressures produce substantially the same result as higher pressures used in connection with the injection of adults. There is some difference also of course in the distance of the fascia and muscles from the skin surface at different locations of the body, all of which must be taken into consideration.

I have also found that people with highly pigmented skin have more resistant tissues than light complexioned people and that everything else being equal injections go deeper in the anterior surface of the body than into the posterior surface thereof. The toughness of the fascia compared to the fatty tissues and the greater toughness of the muscle fibres provide more or less definite obstructions so that pressures are not too critical and can vary over a reasonable range and yet insure any injection desired whether intradermal, intrafat, intrafascia or intramuscular.

The most important feature of my hypo-jet injector over the prior art consists of providing for two-stage jet operation so that a relatively light spring can be used first on a primary plunger 62 to produce high pressure required for jet penetration during a fraction of the expansion of the spring when released, and the low pressure follow-through jet produced by simultaneous movement of the primary and secondary plungers to then utilize the remaining energy in the spring to accomplish follow-through introduction of liquid at only the necessary pressure to make an injection instead of continuing high pressure penetration. For instance, the dotted line *c, e'* represents the pressure curve resulting from the use of a single plunger and a spring 4 or 5 times as heavy as required at 56 in Figure 1 in order to secure the required initial high pressure for a penetrating jet. This pressure might necessarily be as high as 10,000 PSI but for injection after penetrating only 2,000 PSI would be required. If the 10,000 PSI pressure is continued it would cause the jet to continue penetrating deeper and deeper and the necessary dispersion of the medicament at the desired subcutaneous level could not be controlled. It is obviously important therefore that after the penetrating jet has reached the desired level the pressure be reduced so that lateral injection then occurs as illustrated in Figure 5. In accordance with Figures 9 to 13 a single plunger and two springs of different strength can also accomplish the desired two-stage jet action.

The reduction of the jet pressure from high for penetration to low for follow-through is also of great importance when a considerable quantity of material is to be injected. The two-stage operation of my injector is therefore a necessity in the making of successful, accurately controlled jet injections of maximum dosage required for practical purposes.

Some changes may be made in the construction and arrangement of the parts of my injector without departing from the invention, and it is my intention to cover by my claims any modified forms of structure or use of mechanical equivalents which may be reasonably included within their scope.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is :—

1. A hypo-jet injector for injecting medicament in the form of a liquid from an ampoule through a jet orifice thereof by jet action, including a holder for the ampoule, plunger means within the ampoule to displace the liquid therefrom, and mechanism for operating the plunger means to effect projection of a two-stage jet from the orifice of the ampoule, the first stage producing a high pressure, high velocity penetrating jet and the second stage producing a low pressure follow-through jet issuing from said orifice, and the pressure being sharply dropped from high to low between the two stages.

2. A hypo-jet injector, as set forth in claim 1, including in the mechanism for operating the plunger, means for applying a predetermined high pressure to cause penetration of the tissue and open a channel through the same of the desired depth, and then applying lower pressure of a value to discontinue further penetration while maintaining the flow through the channel established by the high pressure jet.

3. A hypo-jet injector, as set forth in claim 2, including in the mechanism for operating the plunger, means for effecting the flow of the medicament remaining in the ampoule upon establishment of the channel at the reduced pressure which is sharply terminated when all the medicament has been injected.

4. A hypo-jet injector, as set forth in claim 1, including in the ampoule a follower above the level of the liquid, the mechanism for operating the plunger also actuating the follower to force the liquid from the jet orifice of the ampoule as a high pressure penetrating jet and subsequently as a low pressure follow-through jet.

5. A hypo-jet injector, as set forth in claim 4, including in the mechanism, a primary plunger for engaging the follower to displace liquid from the jet orifice, and a secondary plunger operative on the follower to move the latter at less pressure for expelling a follow-through jet from the jet orifice into the jet formed opening.

6. A hypo-jet injector, as set forth in claim 5, including means operatively engageable first with the primary plunger, and then with the secondary plunger for moving thereafter both plungers in unison.

7. A hypo-jet injector, as set forth in claim 6, in which the primary plunger is of relatively small size, while the secondary plunger is of greater area, the elements of the mechanism actuating the secondary plunger after predetermined travel of the primary plunger.

8. A hypo-jet injector, as set forth in claims 5 to 7, including as secondary plunger a tubular plunger within which the primary plunger is movable.

9. A hypo-jet injector, as set forth in claim 8, including in the mechanism, common means for initially moving the primary plunger when spaced from the follower in the ampoule to a position of contact therewith and then moving said primary plunger for producing a high pressure penetrating jet from said orifice of the ampoule and thereafter moving both plungers in unison to produce a low pressure follow-through jet.

10. A hypo-jet injector, as set forth in claims 8 and 9, in which the primary plunger is of less cross-sectional size than the area of the ampoule, the plunger being adapted to move the follower in the ampoule to displace liquid at a velocity penetrating the epidermis and tissue, the secondary plunger having a cross-sectional area of the same value as the ampoule and being operative to move the follower at less pressure for expelling a follow-through jet from the orifice of the ampoule.

11. A hypo-jet injector, as set forth in claim 5, including on the ampoule a jet orifice, the edge of which is adapted to be sealed relative to the epidermis, the means for initially moving the primary plunger being adapted to produce a high pressure penetrating jet which opens a channel in the tissues underlying the epidermis, and including secondary means for then moving the plunger to produce a low pressure jet projected from the jet orifice into the channel and dispersed laterally from the bottom of the channel.

12. A hypo-jet injector, substantially as described and shown in Figures 1 to 5 inclusive, and for the purpose set forth.

13. A hypo-jet injector, substantially as described and shown with reference to Figures 7 and 7a, and for the purpose set forth.

14. A hypo-jet injector, substantially as described and shown with reference to Figures 9 to 11, inclusive, and for the purpose set forth.

15. A hypo-jet injector, substantially as described and shown with reference to Figures 12 and 13, inclusive, and for the purpose set forth.

Dated this 7th day of July, 1949.

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681,098 COMPLETE SPECIFICATION
3 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

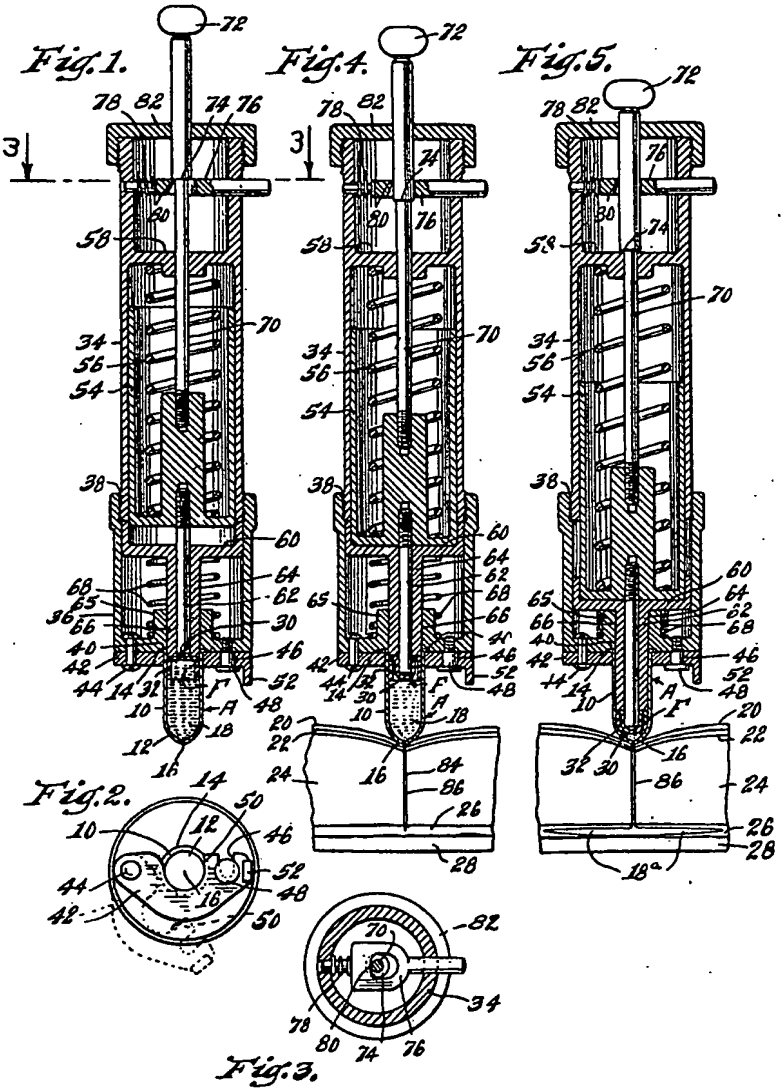


Fig. 6.

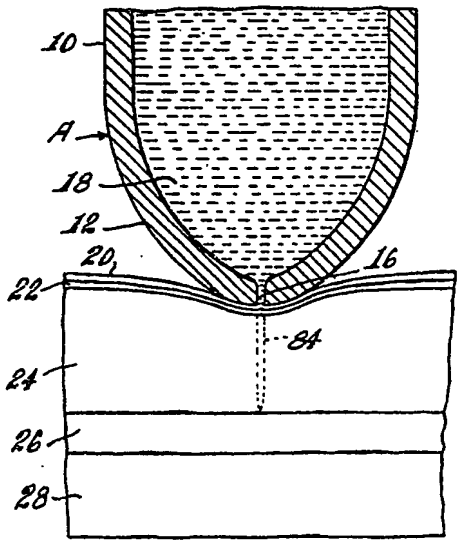


Fig. 7.

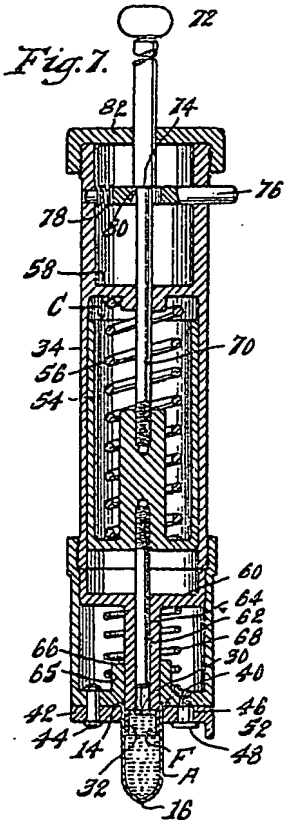
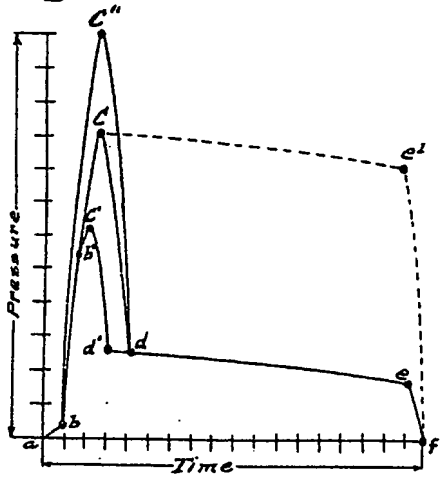


Fig. 8.



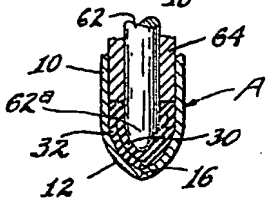


Fig. 7a.

681,098 COMPLETE SPECIFICATION
3 SHEETS

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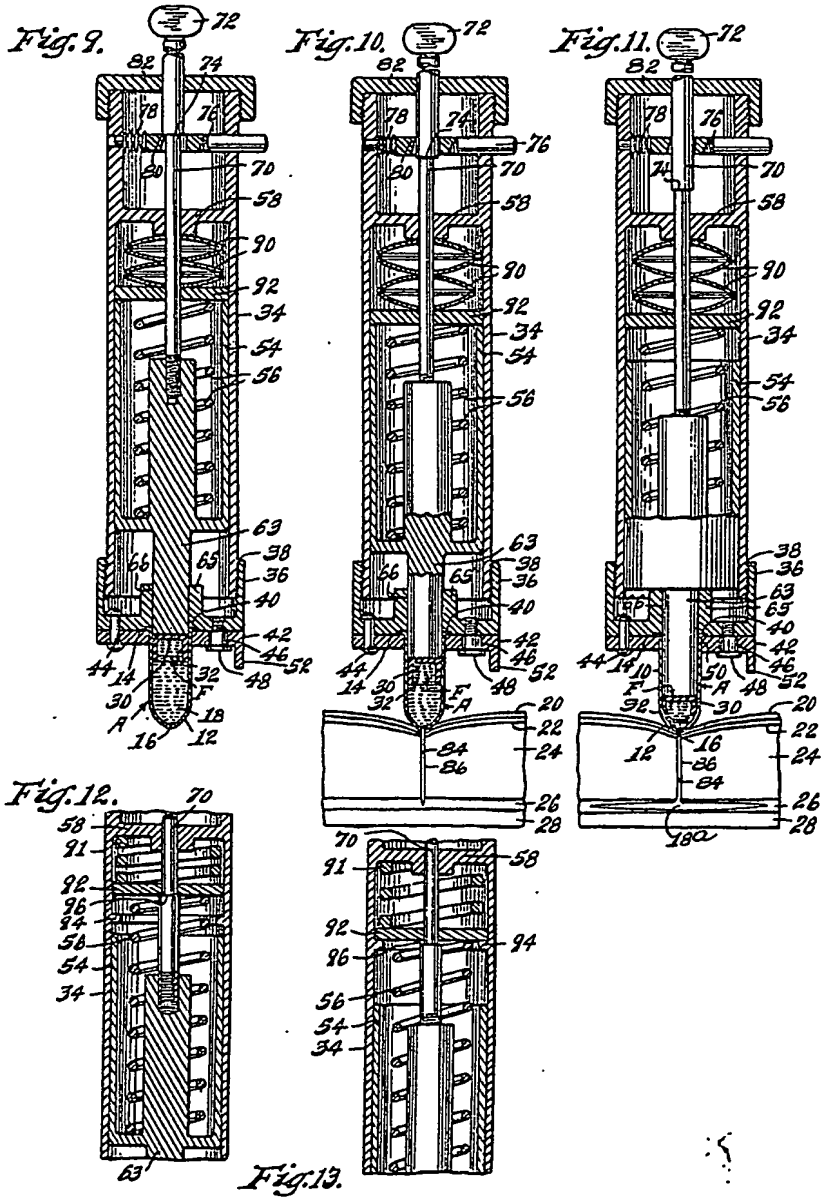
SHEETS 2 & 3



681,098 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 2 & 3

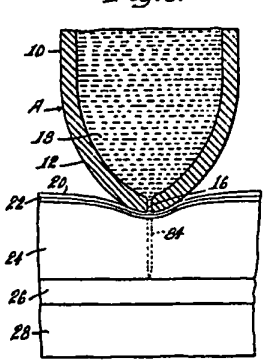


Fig. 6.

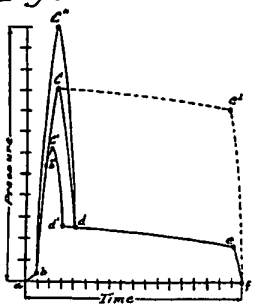


Fig. 8.

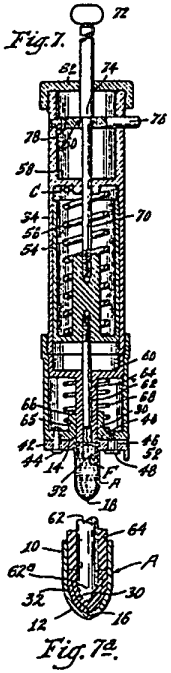


Fig. 7.
Fig. 7a.